10

CLIENT 16

CLIENT 16

Access
Network 14

20

Backbone
Network 12

CONTENT
PROVIDER 18

FIG. 1 – Data Network with Edge Server

FIG. 2 – *Service-Level Controlled Server*

Server 1

Server 2

Server 3

Server 4

Server 5

Server 6

FIG 3 – Six Node Cluster

Incoming Request

36

Unmodified
Application

32

Unmodified
Linux OS

34

Service-
Level
Manager

30

Service-Level-Aware Cluster File System (SL/FS)

38

Service-Level-Aware Cluster Block Service (SL/BS)

40

Fig. 4 – Service-Level Flow for Unmodified Applications

Incoming Request

36

Service-Level Manager

30

Slightly Modified Application

200

Service-Level Manager

30

Unmodified Linux OS

34

Service-Level File Open

202

Service-Level-Aware Cluster File System (SL/FS)

38

Service-Level-Aware Cluster Block Service (SL/BS)

40

Service-Level Manager

30

Fig. 5 – Service-Level Flow for Modified Applications

36 —— Incoming Request

190 / Service-Level Insertion process

192 / Insert Service Level in Request

32 / Unmodified Application

34 / Unmodified Linux OS

198 / Parse Service Level from Request

38 — Service-Level-Aware Cluster File System (SL/FS)

40 — Service-Level-Aware Cluster Block Service (SL/BS)

30 — Service-Level Manager

Fig. 6 – Service-Level Flow for Unmodified Applications

50

52 — WAIT FOR REQUEST

54 — AVAILABLE CAP? → NO → 56 REJECT OR REDIRECT

58 — RESOLVE TO SERVICE LEVEL OPTIONS

59 — RESOLVE TO BEST AVAILABLE SERVICE LEVEL

64 — ADMIT = YES ? → NO → 66 REJECT or REDIRECT

60 — RESOURCES NEEDED ? → YES → 62 TERMINATE LOWER PRIORITY CONNECTIONS

68 — WITHIN INPUT RATE LMTS? → NO → 70 BUFFER REQUEST UNTIL NEXT SLOT

72 — DECORATE REQUEST (i.e. EMBED SL INFO)

74 — SEND TO BEST APPLICATION ON BEST NODE

76 — SERVER APPLICATION

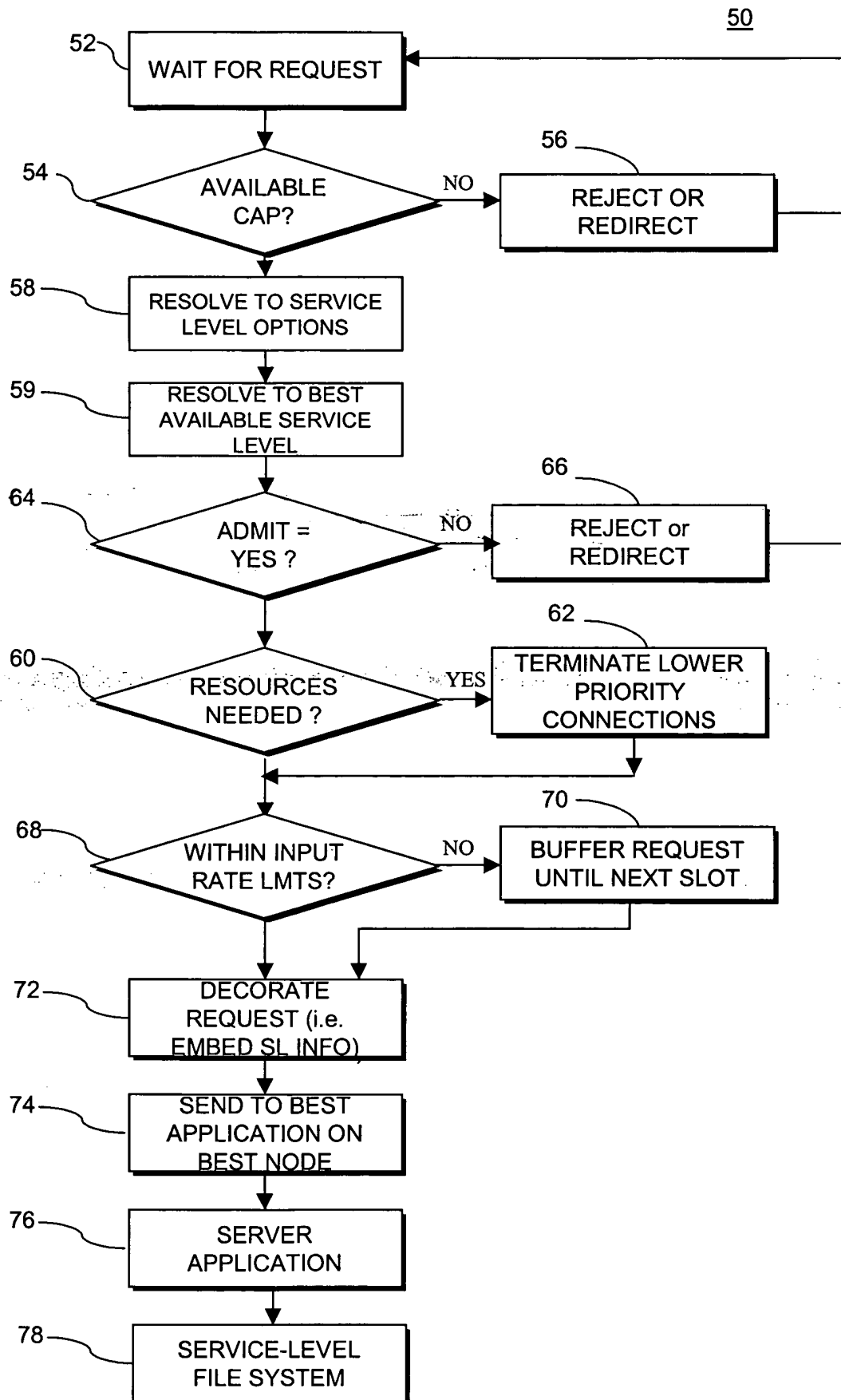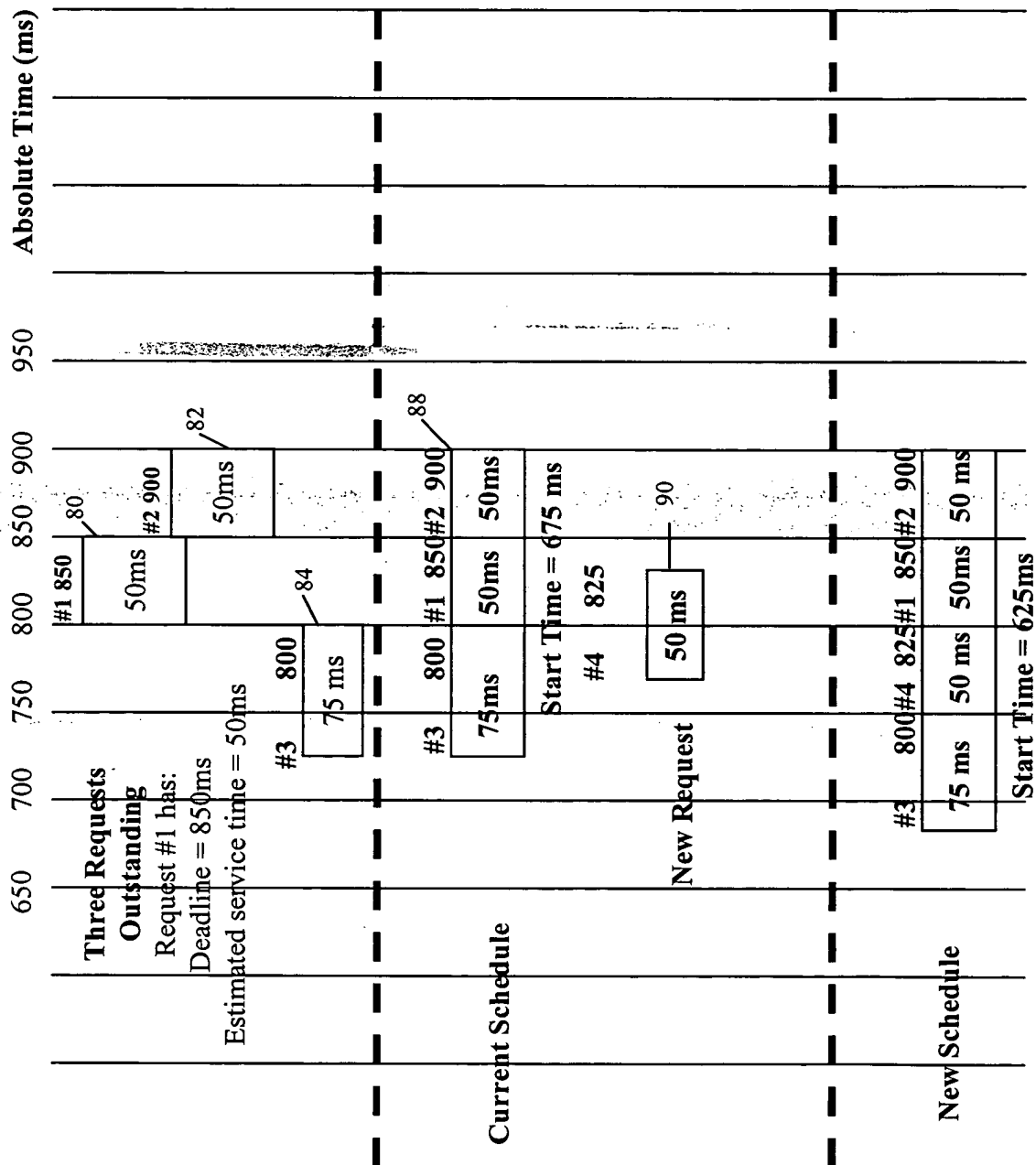78 — SERVICE-LEVEL FILE SYSTEM

FIG. 7 – Service-Level Manager Flow

2081355 1

Fig. 8 - Managing a Disk Schedule with a Single Priority

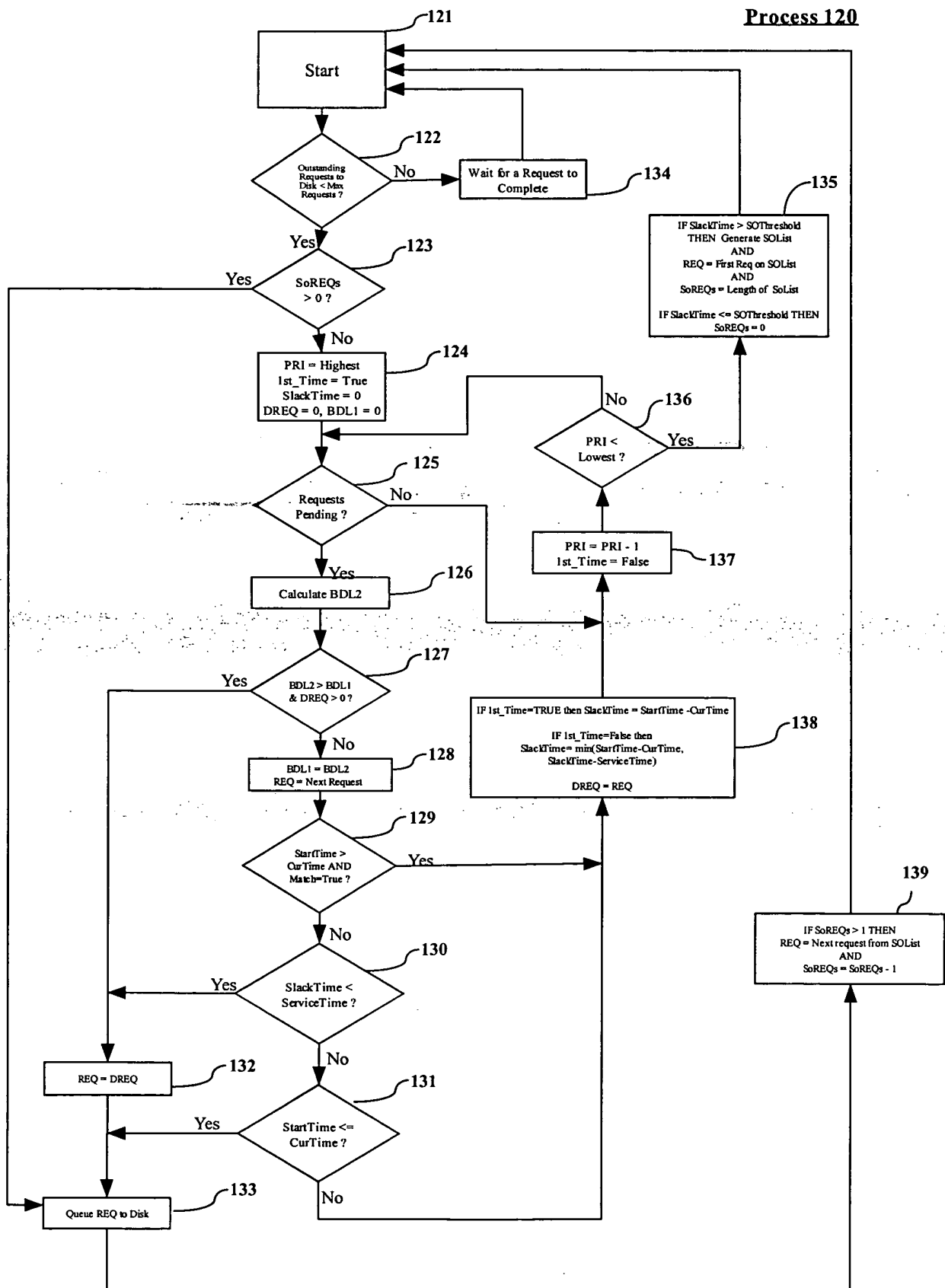Fig. 9 – Managing a Disk Schedule with a Three Priorities

121

Start

122
Outstanding
Requests to
Disk < Max
Requests ?

No → Wait for a Request to Complete — 134

135
IF SlackTime > SOThreshold
THEN Generate SOList
AND
REQ = First Req on SOList
AND
SoREQs = Length of SoList

IF SlackTime <= SOThreshold THEN
SoREQs = 0

Yes

123
SoREQs
> 0 ?

Yes

No

124
PRI = Highest
1st_Time = True
SlackTime = 0
DREQ = 0, BDL1 = 0

No — 136
PRI <
Lowest ?

Yes

125
Requests
Pending ?

No

137
PRI = PRI - 1
1st_Time = False

Yes

126
Calculate BDL2

127
BDL2 > BDL1
& DREQ > 0 ?

Yes

No

138
IF 1st_Time=TRUE then SlackTime = StartTime -CurTime

IF 1st_Time=False then
SlackTime= min(StartTime-CurTime,
SlackTime-ServiceTime)

DREQ = REQ

128
BDL1 = BDL2
REQ = Next Request

129
StartTime >
CurTime AND
Match=True ?

Yes

No

130
SlackTime <
ServiceTime ?

Yes

No

139
IF SoREQs > 1 THEN
REQ = Next request from SOList
AND
SoREQs = SoREQs - 1

132
REQ = DREQ

131
StartTime <=
CurTime ?

Yes

No

133
Queue REQ to Disk

Fig. 10 – Service-Level Disk Scheduler

Storigen Edge Storage Server Management - Microsoft Internet Explorer

File   Edit   View   Favorites   Tools   Help

Back   Search   Favorites   History

Address   https://storigen2u37:7227/portal/PortalFrameset=yes&portalAction=accounts   Go   Links »

Storigen   Monitor | Repair | Configure | Applications | Subscribers | Password | Help   User: esadmin Host: storigen2u   Logo

Accounts and Contracts | Statistics | Billing Information

Account and Contract Management

Select Account: customer ▼   Search for: _____ go   Refresh   New Account

Account Information

Notes:

Name: customer
Number (optional):
FTP User: customer
Domain name:

Edit   Suspend   Delete

Aggregate Bandwidth (mbps)

Priority	Allocated	Available
Gold	200 600	75%
Silver	100 700	88%
Bronze	50 750	94%

Delivery Contracts (kbps)

Directory Name	Gold	Silver	Bronze
/	0	0	0
/audio	0	128	0
/static	0	0	32
/video	500	0	0

Edit

Local intranet

FIG. 11 – Example of Service-Level Management Interface

2065068_1

DIRECTORY

/ CUSTOMER

/ VIDEO	/ AUDIO	/ STATIC
movie.wmv	song.wma	file.html
movie.rm	song.rm	file.gif
movie.mov	song.mp3	file.jpg
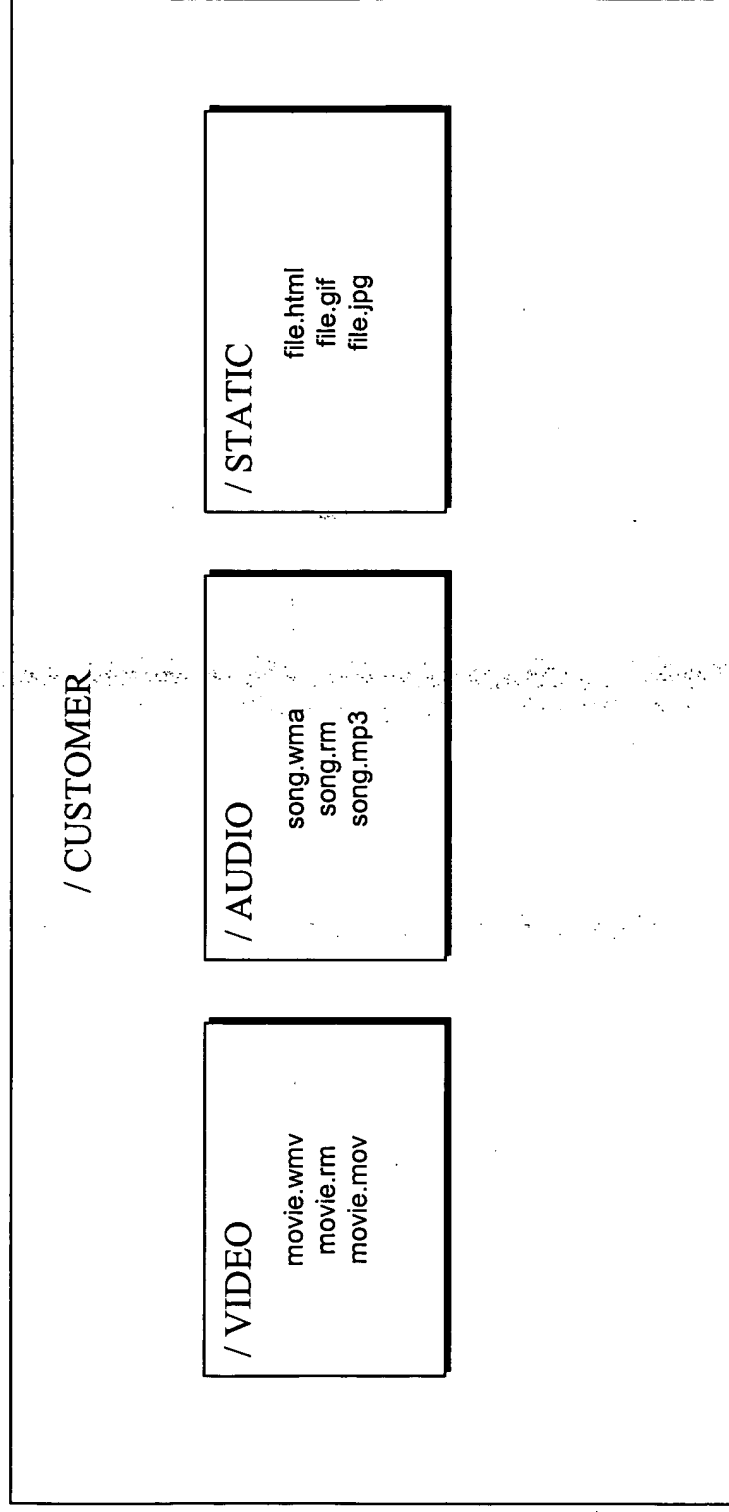
FIG. 12 – Example of Directory Hierarchy for A Customer Account

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210

212

Based on request attributes generate inputs
(Content/Requester/Application group identification)
required for Service Level Resolver

214

Resolve Inputs to a set of Service Level options
based on
(Content/Requester/Application group identification)
Service Level Tables

218

Resolve Service Level options to the best available
Service Level based on committed capacity
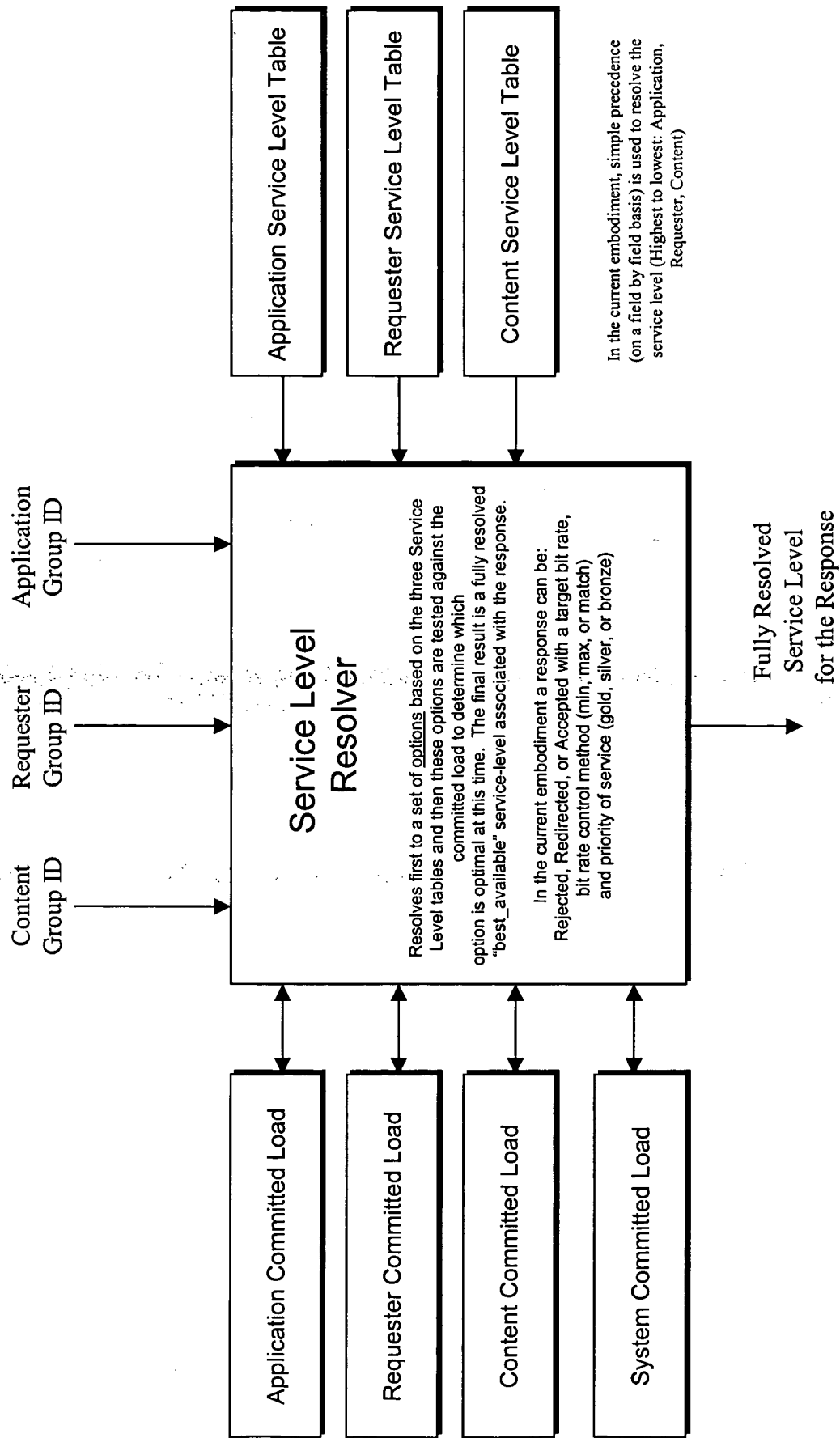
FIG. 13 – Process to Resolve Service Levels

Application Service Level Table

Requester Service Level Table

Content Service Level Table

In the current embodiment, simple precedence (on a field by field basis) is used to resolve the service level (Highest to lowest: Application, Requester, Content)

Application Group ID

Requester Group ID

Content Group ID

Service Level Resolver

Resolves first to a set of options based on the three Service Level tables and then these options are tested against the committed load to determine which option is optimal at this time. The final result is a fully resolved "best_available" service-level associated with the response.

In the current embodiment a response can be: Rejected, Redirected, or Accepted with a target bit rate, bit rate control method (min, max, or match) and priority of service (gold, silver, or bronze)

Application Committed Load

Requester Committed Load

Content Committed Load

System Committed Load

Fully Resolved Service Level for the Response

FIG. 14 – Service-Level Resolver

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xGID	Priority	Aggregate Bandwidth (Mbps)	Individual Response Bit Rate (Kbps)	Bit Rate Control	On "No Admission"	URL for Redirection and Network QOS Settings
0001	GOLD	100	1.000	Min	Redirect	http://redirect1.com
0001	SILVER	100	0.500	Min	Reject	-
0001	BRONZE	200	0.100	Max	Reject	-
0002	GOLD	50	1.000	Min	Redirect	http://redirect2.com
0002	SILVER	0	0.000	Min	Reject	-
0002	BRONZE	0	0.000	Min	Reject	-

FIG. 15 - Service Level Table Structure

Priority Number (PN)	Service-level "Attribute"	"Color-based" Priority within a given Service-Level "Source"
10	Application	GOLD
9	Requester	GOLD
8	Content	GOLD
7	Application	SILVER
6	Requester	SILVER
5	Content	SILVER
4	Application	BRONZE
3	Requester	BRONZE
2	Content	BRONZE

In the current embodiment, 1 = lowest priority.

A given priority level in general is not oversubscribed, but may allocate the entire capacity of the system. The system is over-subscribed as a result of the aggregate capacity allocated by all priority levels.

FIG. 16 - Priority Assignment Example

Application GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	-	-	-	-	-
0001	-	-	-	-	-

Requester GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	-	-	-	-	-
0001	-	-	-	-	-

Content GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0004	8	100	1.000	Min	Redirect
0004	5	50	0.500	Min	Reject

In this example, the content-based service levels comprise the response options:

Service Level Options	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
Option #1	8	100	1.000	Min	Redirect
Option #2	5	50	0.500	Min	Reject

There is more than 1Mbps spare capacity at Priority 8; therefore the response will be:

Best Available Service Level	Priority	Response Bit Rate	Bit Rate Control	Action
Option #1	8	1.000	Min	Admit

In the current embodiment, -1 in a field indicates no entry (marked '-' above)

FIG. 17 - Content-based SL Example

Application GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	-	-	-	-	-
0001	-	-	-	-	-

Requester GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	9	6	2.000	Min	Redirect
0001	6	2	0.500	Min	Reject

Content GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0004	-	-	-	-	-
0004	-	-	-	-	-

In this example, the request-based service levels comprise the response options:

Response Options	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
Option #1	9	6	2.000	Min	Redirect
Option #2	6	2	0.500	Min	Reject

In this example, there is more than 2Mbps spare capacity at Priority 9; therefore the response will be:

Resolved Response	Priority		Response Bit Rate	Bit Rate Control	Action
Option #1	9		2.000	Min	Admit

FIG. 18 – Requester-based SL Example

Application GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	10	100	1.000	Min	Redirect
0001	7	50	0.500	Min	Reject

Requester GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	-	-	-	-	-
0001	-	-	-	-	-

Content GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0004	-	-	-	-	-
0004	-	-	-	-	-

In this example, the content-based service levels comprise the response options:

Response Options	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
Option #1	10	100	1.000	Min	Redirect
Option #2	7	50	0.500	Min	Reject

There is no capacity at priority 10 for this request but there is more than 0.5 Mbps spare capacity at Priority 7; therefore the response will be:

Resolved Response	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	Action
Option #1	7		0.500	Min	Admit

FIG. 19 – Application-based SL Example

Lower Priority Application Service overrides Standard Content Service

Application GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	4	75	-	-	-
0001	-	-	-	-	-

Requester GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	-	-	-	-	-
0001	-	-	-	-	-

Content GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0004	8	100	1.000	Min	Redirect
0004	5	50	0.500	Min	Reject

In this example, the application-based service level defines the priority (it has precedence...).
Since the application-based priority is lower than the priorities of the other potential service levels, there will be only one option.
The content-based service level for the priority closest to the app-based priority defines the rest of the option:

Response Options	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
Option#1	4	75	0.500	Min	Reject
Option#2	-	-	-	-	-

There is more than 0.5 Mbps spare capacity at Priority 4; therefore the response will be:

Resolved Response	Priority	Response Bit Rate	Bit Rate Control	Action
Option#1	4	0.500	Min	Admit

FIG. 20 - Application+Content-based SL Example

Premium Requester Service overrides Standard Content Service

Application GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	-	-	-	-	-
0001	-	-	-	-	-

Requester GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0001	9	1	-	-	-
0001	-	-	-	-	-

| Content GID	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No Admission"
0004	8	100	1.000	Min	Redirect
0004	5	50	0.500	Min	Reject to www.redirect1.com

In this example, the requester-based service level defines the priority of Option#1

The content-based service level for the priority closest to the app-based priority defines the rest of Option#1:

Option 2 and 3 are taken directly from the Content Service Level entries.

Response Options	Priority	Aggregate BW	Response Bit Rate	Bit Rate Control	On "No-Admission"
Option#1	9	1	1.000	Min	Reject to www.redirect1.com
Option#2	8	100	1.000	Min	Redirect
Option#3	5	50	0.500	Min	Reject to www.redirect1-com

There is 1 Mbps spare capacity at Priority 9; therefore the response will be:

Resolved Response	Priority	Response Bit Rate	Bit Rate Control	Action
Option#1	9	1.000	Min	Admit

FIG. 21 - Requester+Content-based SL Example
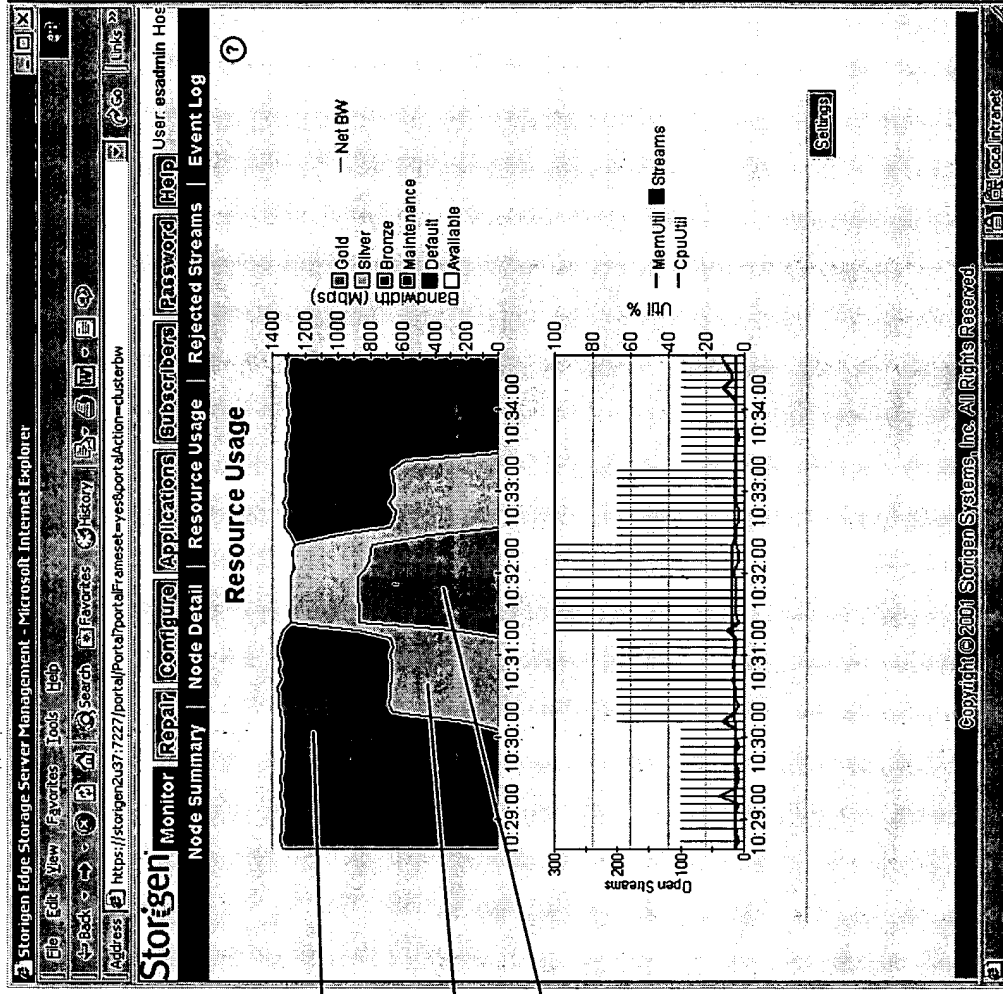
Bronze: 100 Users

Silver: 100 Users

Gold: 100 Users

FIG. 22 – Mixed Service Level Workload